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Flipped Learning as a Paradigm Shift in Architectural Education

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Abstract

The target of Education for Sustainable Development is to make people creative and lifelong learners. Over the past years, architectural education has faced challenges of embedding innovation and creativity into its programs. That calls the graduates to be more skilled in the human dimensions of professional practice. So, architectural education has a great role in developing students' skills and attitudes needed for professional practice and in fostering continued learning throughout the lifetime. Architectural education that establishes a base for lifelong learning is the best way to face global challenges of the 21st century. More effective methods are needed in introducing lecture-based courses in architectural education to meet the 21st century proper skills. Lecture-based courses are often associated with teacher-centered method that inhibits the possibility to apply such skills. This paper suggests applying the concept of Flipped Learning that stands on active learning and its related pedagogy; Problem-Based Learning. The paper aims to; 1) draw a clear vision of flipped learning relying on its pillars; pedagogy, technology, and space, 2) investigate the challenges face such concept and the opportunities, 3) explore the mechanism of the Problem-Based Learning pedagogy, 4) review the previous promulgated literature of applying PBL within the framework of FL on LBCs in the architectural curriculum, and 5) apply Problem-Based Learning pedagogy on Lighting and Acoustics as a lecture-based course. The paper concludes by; establishing a conceptual approach for the flipped classroom environment, and devising a proposal of Lighting and Acoustics course in a framework of Problem-Based Learning pedagogy.

Keywords: flipped learning, flipped classroom, architectural education, problem-based learning, lecture-based courses

1. An Introduction to the Subject

Education for sustainable development (ESD) is the UN initiative. Grounded on this initiative, critical thinking, team-working, creativity and self-direction are the most proper skills of the 21st century. UN initiative aims to help people develop their skills, use their knowledge to make responsible decisions, and act upon themselves to find the way to a more sustainable future. It seeks to make people being creative, efficient communicators, collaborators, critical thinkers, and lifelong learners (Armstrong, 2011; Bjørke, 2014; Waas et al., 2012).

Universities are responsible for developing such skills among students and making them lifelong learners. Architectural education, in particular, has faced global challenges to instill innovation and creativity in students and to develop their professional attitudes. The recent changes in society and construction industry related to the technological advances and the rapid growth of information show the need for more effective cross-disciplinary teamwork amongst industry professionals (Nicol & Pilling, 2005; Triantafyllou, Timcenko, & Kofoed, 2015). That calls the architects to the facilitators who listen, respond, collaborate and utilize their skills to make responsive solutions (Brosnan, 2015). Nevertheless, many architecture graduates start on marginal careers don't cope with construction industry when they leave the formal study. As a result, they need to update their knowledge and skills many times over the lifetime. They need to be more skilled in the human dimensions of professional practice and more adaptable, flexible and versatile over the extent of their professional careers. So, architectural education has a great role in developing students' skills and attitudes needed for professional practice and fostering continues learning throughout the lifetime (Nicol & Pilling, 2005). Architectural education that establishes a base for lifelong learning is the best way to face global challenges of the 21st century (ACSA). In architectural education, many courses have been delivered as lecture-based courses (LBCs) which are often associated with teacher-based method that inhibits the possibility to apply the 21st century proper skills.

The teacher-centered learning (TCL) approach is still extensively used as the teaching method in higher educational institutions in many developing countries. In the (TCL), the teacher delivers and propagates knowledge among students in a classroom and the students are the passive learners or the recipients (Marks, Ketchman, Riley, Brown, & Bilec, 2014). That makes the teaching process in a one-way direction. (TCL) may be economically effective when teaching a large number of students in a relatively short time; nevertheless, students acquire a low level of thinking skills. They listen, memorize, and repeat the delivered knowledge (Danker, 2015, pp. 171-186; Marks et al., 2014).

To activate education within the framework of sustainability, it is important to construct the self-concept of the students as lifelong learners. Teaching approaches must focus on elements relating to the processes of learning, rather than the accumulation of knowledge. Students learn better through the use of teaching methods that are active and participatory and are related to real-life situations (Mohd-Yusof, Alwi, Sadikin, & Abdul-Aziz, 2015; Thomas, 2009).

To make the conceptual level of thinking, students need to be active seekers, take the responsibility for their own learning. That is why active learning has been supported in recent years by many higher educational institutions globally where the class has been turned from a traditional lecture classroom (TCR) to a flipped classroom (FCR) (Danker, 2015, pp. 171-186; Marks et al., 2014)

When we talk about sustainability in architecture education, we address two main issues, teaching subjects, and teaching methods. There is no doubt that the concept of sustainability is expressed in many architectural curricula in the large majority of higher education institutions, even it is still in its initial stages (Benkari, 2013). The Integration of sustainability in higher education is often limited on greening campus, research initiatives, and particular environmental courses/programs, while the pedagogical innovation towards sustainability has been much slower to be developed (Armstrong, 2011; Waas et al., 2012).

The field of this paper deals with achieving sustainability through the pedagogical method the architectural courses delivered to students. From author's point of view, sustainable education is the bridge between education and practice. University here is a facilitator provides students with relatively little experience and multidisciplinary problem-solving approaches to face open-ended problems, the type often faced in practice. The research calls for changing the way the (LBCs) delivered to students by applying the concept of Flipped Learning (FL) model and its related pedagogies. In FL, the lecture was shifted outside the classroom to be replaced by activities in the classroom, permitting to active learning.

2. Method

This paper deals with two main parts. *The first part* is a review that targets draw a comprehensive and plain concept of FL basing on its staple pillars; pedagogy, technology, and space. The anticipated output of this review is a comprehensive understanding of the basic requirements for the establishment of FCR. To complete the full picture of FL, it is significance to explore the mechanism of the determined interactive PBL pedagogy, and investigate the criticisms and limitations encounter such concept and address the opportunities. In order to that, data have been collected from the internet and from the literature resources in this regard.

The way the LBCs delivered in several universities, particularly in the developing world, doesn't keep pace with FL concept. LBCs are often delivered based on the TCL that already has been used in many architectural programs in many faculties so far. This paper suggests applying the concept of FL on LBCs. First, it was important to determine the extent of the impact and the share of these courses in an existing architectural program. So, an analytical study done by this paper to measure the weight of these courses delivered in architecture and urban planning department, faculty of engineering, in Port Said University, together with investigating the subject areas covered by LBCs in this program. Within this area, *the second part* reviews the published literature with respect to LBCs and PBL in architectural programs to draw lessons learned from them with respect to PBL pedagogy. That is, in order to put a theoretical proposal of Lighting and Acoustics course based on PBL pedagogy as it has been taught by the author for more than 5 years.

3. FL Background Information

In the FCR, students gain first exposure to new material outside of class, via lecture videos, and then use class time to do the application, analysis, synthesis, and/or evaluation in with the assistance of their peers and instructor, through problem-solving, discussion, or debates (Brame, 2013). FL is based on active learning. Active learning built on the student-centered approach that emphasizes learning by doing (Uskov, Howlett, & Jain, 2015). Students are more interactive and more engaged in learning through application and practice. Students don't only make their own knowledge as a result of interaction with their environment, they also participate in

the process of constructing knowledge in their learning community as the FCRs concept puts the responsibility for learning more on the shoulders of the students. Active learning creates face-to-face time to have much deeper interaction between the teacher and student as they participate and interact with case studies, and discuss problems. Students reach the highest level of learning when they apply the materials in a way that make sense to them through creating individual solutions. In the FCR, the role of the instructor is to help students, and students also help each others, which known as peer-based learning (Danker, 2015). In FL, the instructor starts with the expected results, the intended learning outcomes (ILOs), rather than starts with the content. This design concept is called Backwards Design (Bjørke, 2014).

The First exposure to material outside of class is via lecture videos, PowerPoint presentations with voice-over, and/or printable PowerPoint slides. These lecture videos can be prepared by screencasting and provided on the instructor's YouTube channel, or they can be found online from YouTube, the Khan Academy, MIT's Open-Course-Ware, MOOC platforms like Coursera, or other similar sources (Brame, 2013). Watching lecture videos at home has an advantage; students have control over the media they watched, they have the ability to review the parts that misunderstood and the parts that are of particular interest (Danker, 2015). During FCR, the instructor limits the time he lectures and increases the time students spend embarking on solving interesting problems. The instructor circulates among the students to check in on their understanding, answer their questions and motivate them to think more deeply (Derekbruff, 2012). Figure 1 illustrates the difference between FL model and traditional learning (TL) model.

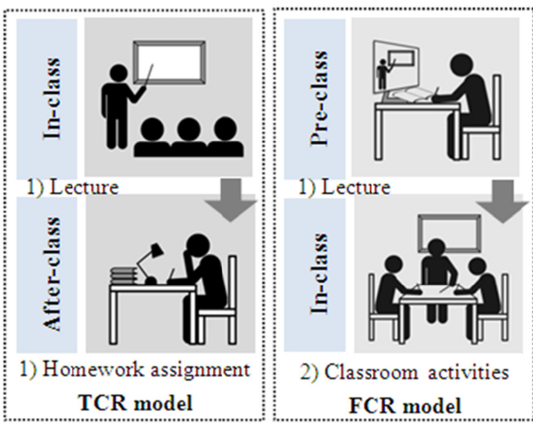

Figure 1. TCR versus FCR

3.1 Key Elements of FL Environment

The change of the new classroom design from a traditional concept to FCR requires a change driven by the integration of the three key elements of a successful learning environment; pedagogy, technology, and space (Steelcase, 2015). Every element will be discussed in the following section.

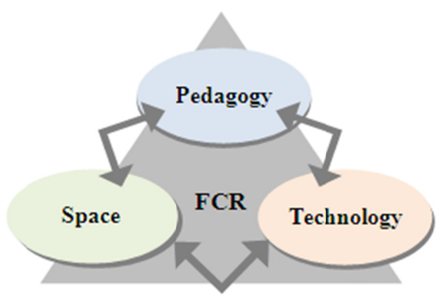

Figure 2. The three related key elements of FCR. Source: (Steelcase, 2015)

3.1.1 Pedagogy

FL is grounded on the experience of active learning. The instructional techniques of active learning are PBL and peer-learning (Danker, 2015). PBL method has been used in teaching already more than 40 years across various disciplines such as medicine, architecture, engineering, economics, law, and mathematics. In such method, students were given problems based on practical examples from the real world and they were assigned to find solutions to these problems in a group. In order to solve the problems, students need to gain new knowledge; as a result, students learn both calling for knowledge and problem-solving skills. In PBL, the students, not the instructor, are responsible for searching for information from various resources and determining what information and analyses are needed to resolve the problem. Grounding on that, PBL method also supports life-long-learning as graduates, in their professional practice, are often subjected to the need to update their knowledge to cope with the rapid development. As PBL accompanied with team-working, it fosters the development of communication and collaboration that lead to experience a simulated real-world working and professional environment. So, PBL and peer learning are often related. So, PBL helps students to develop holistic thinking, flexible knowledge, effective collaboration skills, self-directed learning, and effective problem-solving skills (Franssila, 2007; Steinemann, 2003; Thomas, 2009; Triantafyllou, 2015).

Based on the above and along the same theory of Thomas (2009); the development of thinking based on PBL is the critical element in education related to sustainability (Thomas, 2009).

a) Mechanism of the PBL process

In the PBL, the role of the instructor is to organize the process. He gives the students the stimulus; the actual problem or the case to be solved. He controls the process, guides the students, and provides them with advice and concepts when necessary. Therefore, it could be said that the instructor role is likely an active listener. The number of students in the PBL group ranges between 5-8 students. In every group, one student works as a discussion leader and another one as a secretary. These two roles are changed regularly among students in the group. The discussion leader manages and activates the roles of the rest of the students. He analyzes and summarizes students' points and opinions and put questions to ensure the participation of each student in the group. The role of the secretary is to make notes of discussions during the learning process. The role of the secretary is very crucial as the notes he puts are essential for the next step of the PBL process. He can use the whiteboards to lead the discussion during PBL. The role of the other students is to participate in discussions and offer their opinions and knowledge of the subject in the use of the whole group (see figure 3). They have to learn the skill of good listening too (Franssila, 2007).

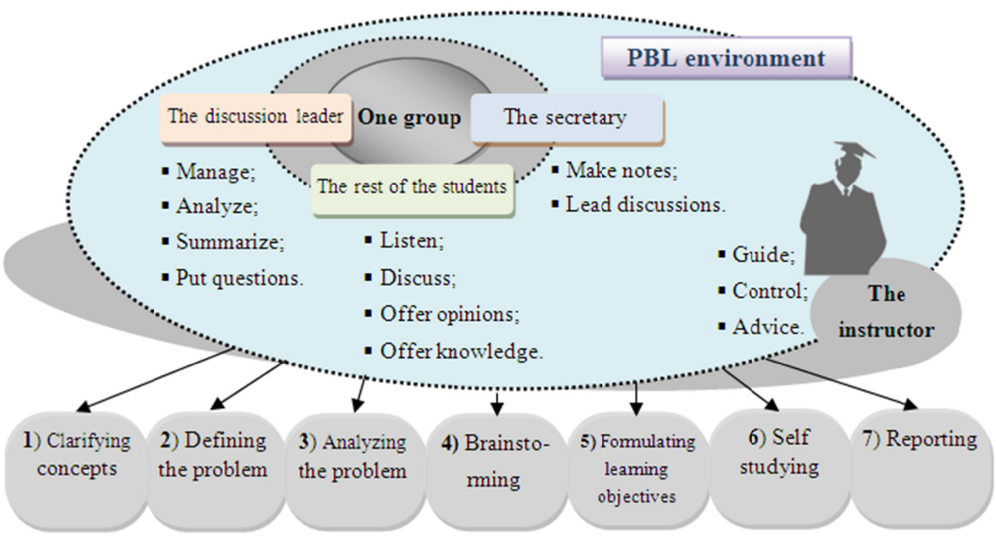

Figure 3. The roles of the participants in PBL environment, and PBL steps. Source: Drawn by the Author from (Franssila, 2007)

3.1.2 Technology

As a consequence of digital technology stream, students have more opportunities in contact with digital

electronic products such as personal computers, tablets, and smart phones and with Internet applications (Tsai, Shen, & Lu, 2015). Today's students are adept with technology. They have adopted practices such as text-messaging, Googling, and social networking. They consider the Internet, not the library, their information universe. They Collect, analyze, display, and disseminate knowledge using IT (Lomas & Oblinger, 2006; Oblinger, 2006). Unfortunately, their interest about technology revolves around playing games or browsing social media. Tsai et al. (2015) stated that the time spent by the graduated students in USA on computer games, email, and social media is almost twice the time spent on studying. But the positive side that there are many opportunities for online learning (Tsai et al., 2015). The use of online learning has begun to emerge in higher education because it provides flexible access to content and instruction at any time and from any place, and due to its cost-effectiveness, in addition to the benefits of asynchronous discourses compare to the synchronous-type discourses (Castle & McGuire, 2010). The FCR shows a positive use of the technology and Internet (Tsai et al., 2015).

In higher education, it would be hard to identify a discipline without IT aid (Oblinger, 2006). The integration of information technology into higher education learning environments plays an important role in the preparation for the 21st century labour market. As the operation of the economy and society is being transformed by information technology, and societal trends call for productivity, competition, career preparation, teaching and learning enhancement; universities should meet the requirements of the future and take its role in preparing students for lifelong learning as technology continues to advance (Callahan, 2004).

Media-equipped classroom with both analog and digital connection is a priority. Analog tools alone are now being to fade as the AV/IT (Audiovisual/Information Technology) world is evolving rapidly. FCRs design requires involving both tools, digital and analog tools (PrincetonUniversity, 2013).

Digital Tools: AV/IT supports the information flow between students and instructor. The locations and arrangements of students and instructor determine the kinds of technologies that best support the various interactions. These interactions include; 1) individuals, 2) small groups, 3) large sized groups, 4) the whole class, and 5) multi-modal layouts (a combination of two or more of the configurations within the same space). Digital tools include equipments such as digital HDMI (High-Definition Multimedia Interface) that replaces VGA analog, and HDVC (High-Definition Video Conference) that allows teams in remote locations to connect to host classroom. Such digital tools include the use of BYODs (Bring Your Own Device) such as laptops, tablets, and smart phones. Mobile displays in FCRs are required to accommodate mobility of students and of information among the class as when a small group needs to share their work with a larger group. The Mediascape tools were developed to address this need. This digital tool supports remote collaboration, digital design presentations, and lecturing with digital media. In limited classroom areas that don't allow more spaces for individual work spaces, a possible way to address that problem is providing sets of noise-cancelling headphones for student use (Bergmann & Sams, 2014; Gee, 2006; PrincetonUniversity, 2013; Steelcase, 2015).

The Infrastructure installations (in ceilings, walls, and floors) related to such technologies should consider furniture easily moving such as seats, tables and instructor lecterns, and support different teaching and learning styles (PrincetonUniversity, 2015). Power and data access and location needed to be mobile as possible, predicting their locations should also be considered (Gee, 2006). To support the infrastructure of these digital tools, a wireless IT networks are needed. It must accommodate the number of students on the network at any time. Adequate power to support numerous devices is also necessary. Although the cost of integrating digital connections is more expensive, their cost over time is considerably less (PrincetonUniversity, 2013).

Analog tools: However, analog tools cannot be dispensed in furnishing FCRs. Verb whiteboards, whether fixed or huddle wall track, allow information to remain visible for the local team. It extends the collaboration to the vertical surface (Steelcase, 2015).

3.1.3 Space

There is no doubt that classroom design has a direct impact on "learning"; the central activity of universities (Oblinger, 2006). A study conducted by a team of Steelcase Education researchers, in collaboration with academic researchers in Canada and the United States (2015) found that classroom design influences student engagement that is by turn widely recognized as a highly probable indicator of student success. They found that classroom design that supports active learning increases student's engagement compared to TCR with row-by-column seating. The majority of classrooms in use today were built for the conventional stand-and-deliver, sit-and-listen pedagogy in a passive learning environment. Inflexible layouts and immobile furniture designed for the one-way direction of transmitting information can't support active learning and collaboration, as they inhibit interaction between students, instructor, and content (see Figure 4). With various

active learning pedagogies, such as PBL and peer learning where students need to connect, share information, and discuss solutions (Pearlman, 2013; Steelcase, 2015), classrooms need the flexibility to adapt to different learning preferences. Furthermore, classrooms must support quick transitions between learning modes, and in the same time support digital tools for students' engagement. Every space can be an interactive learning space if it is designed to support the pedagogy and technology and allows instructors to move among groups providing real-time feedback, assessment and direction for students in peer-to-peer learning (Steelcase, 2015).

Learners' attitudes also influence the space's environment. Today's students favour active and participatory learning, the learning style that may not reconcile with sitting in a lecture hall with fixed chairs to the floor. Today's students are highly social. They find great value in face to face interactions and want faculty to promote this connection (Oblinger, 2006). As both form and function should be investigated; pedagogical style, predictability of layout, location of windows and lighting sources, furniture placement, and projection screens and screens' locations should be considered (Princeton University, 2013).

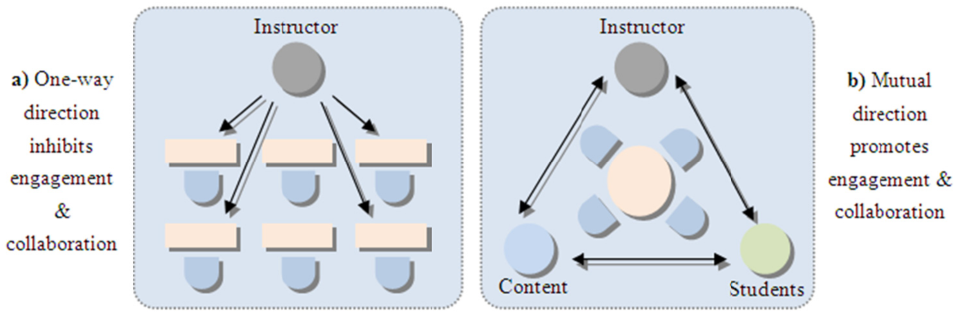

Figure 4. Passive learning classroom (a) versus active learning classroom (b)

To predict the proper space design strategies that are compatible with FCR concept; the author conducted an analytical study of classroom configurations, already designed by Steelcase Education, generated by mixing and matching various core classrooms elements (furniture, technological equipment, displaying screens) to fit different spatial environments (lectures, studios, labs, etc). The designs were studied according to core classroom elements related to the three Key elements of the FCR learning environment; pedagogy, technology, and space. The indicated classroom configurations can be found at (Steelcase, 2015).

Table 1. The core classroom elements related to the three key elements of the learning environment. Source: author after: (Gee, 2006; Princeton University, 2013; Steelcase, 2015)

Key elements of FCR environment	Core classroom elements
Pedagogy style	Lecture
	Small-group work
	Large-group work
	Individual work
	Class discussion
	Activity
	Videoconference
	Decentralized instruction
Technology	Vertical & horizontal surfaces to display
	Access to BYOD
	Wireless Projectors
	Huddle wall track whiteboards
	Mediascape
	Mediascape with HDVC
Space	Visual & physical access
	Clear sightlines to digital and analog content

	Quick transition between various learning styles
	Large space area to accommodate various teaching styles
	Modular furniture
	Swivel seating

It was found that; 1) classes that allow the transition between many of learning styles (convertibility/flexibility) are more favourable than classes with multi-learning fixed zones. The convertible classroom is cost-effective, besides it doesn't need large area; 2) modular furniture allows altering between various learning styles as it allows individual work along with collaboration. The split-table allows both easy assembling and easy separating to work individually or in collaboration. Swivel seating allows versatility and lets students easily having clear sightlines to digital and analog content at any time; 3) multi-modal configuration (that has different multiple configurations in the space at the same time) may suite large classrooms as it requires more area; 4) Mediascape enables groups to share their work and collaborate on projects digitally, besides, Mediascape with HDVC (high-definition video conference) connects distant classrooms. Mediascape can be installed in most classroom designs equipped with power and data access; 5) with respect to the previous considerations, a combination of Node Classroom and Media-Lab represent a good classroom design that likely fits FCR concept. Furthermore, movable and free Mediascape tools can be provided in such design; and 6) as FCR needs multiple display screens, both digital and analog displays; strategic screen placement should be carefully taken into consideration in terms of clear sightlines and lighting. Figure 5 shares in a clear understanding of FCR within a framework of its three pillars; pedagogy, space, and technology.

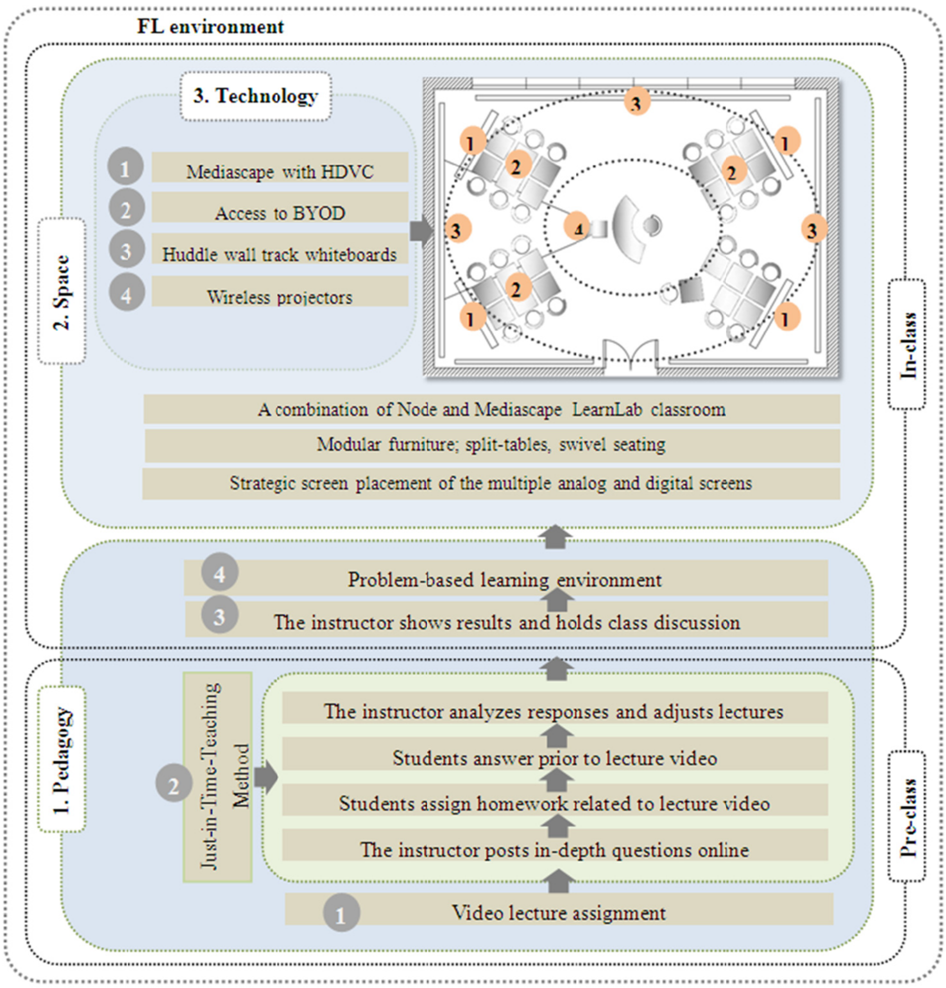

Figure 5. A visualization of FCR within a framework of its three pillars

4. Challenges Facing Flipped Learning Model and Opportunities

Critics have argued that there are some drawbacks encountering FCR model. This paper addresses these drawbacks and investigates the related solutions. These drawbacks vary among; 1) Not all students will complete their assignment (watching lectures videos) pre-class; 2) Teachers concerns about diminishing their role (Triantafyllou, 2015); 3) Students will skip class and only watch the recorded lecture videos at home (HanoverResearch, 2012); 4) The accessibility to online lectures; and 5) The instructor's further effort to integrate out-of-class and in-class activities (Kerr, 2015).

To cope with the first criticism; an assignment-based model, called Just-in-Time-Teaching method (JiTT), was proposed to hold students accountable for the pre-class assignment. In that approach, students are expected to prepare worksheets (writing, problems, etc.) and/or online quizzes before class time. The instructor posts in-depth questions online, and the students graded for how well they use the lecture video in their answers. The students' answers are delivered to the instructor a few hours before class time, allowing the instructor to analyze responses and adjust lectures as needed. The instructor can handle class activities to focus on the elements which students struggling and students can identify areas where they need help, and clarify their thinking about a subject, thereby producing richer in-class discussions. Such method also provides a very valuable window into student thinking. Providing students with an incentive for preparing their tasks before class is important, as "points" is the common language of undergraduates. Automatically grading pre-class worksheets and online quizzes help both instructor and students (Brame, 2013).

For the second criticism, the argument that instructional videos will replace the instructor role is misguided. Skilled professional educators in flipped model are more important and required than ever. They manage when and how to shift the instruction from lecture mode to discussion mode, from individual work to group work, and from one pedagogy to another. Professional educators know how to utilize the affordances of the flipped model to help students gaining conceptual understanding. Professional educators continually observe their students during class time, provide them with feedback relevant at the moment, continuously assess their work, and control classroom chaos. Even though, they take on fewer roles in the FCR (Hamdan, McKnight, McKnight, & Arfstrom, 2013).

For the third criticism, despite a common fear among instructors that access to recorded lectures will impact students' attendance in class; surveys at various institutions in the US and the UK have indicated that access to lecture podcasts generally does not cause students' absence. In another study, students asserted that attending class offer opportunities for interaction among structured learning environment (HanoverResearch, 2012).

For the fourth criticism, since activities outside the lecture hall depend on technology, lecture videos should be available in various accessed means for students such as laptops, tablet computers, smartphones and DVD players. In areas with no access to the Internet, lectures can be downloaded onto DVDs and thumb-drives. The faculty also has a role in overcoming this issue by provisioning lectures on the computers in the library and labs for students to preview the videos before class (Danker, 2015).

For the fifth criticism, although the good preparation of lecture videos is a time consuming, and the careful design and integration between out-of-class and in-class activities need more effort; but then, instead of lecturing in-class, the instructor spends the class time just walking around students, giving advice and guidance. Danker, (2015), argued that the more effort needed could be faced with approaching the model slowly (Danker, 2015).

5. Employing PBL for LBCs in Architectural Curriculum

5.1 Drawbacks of (LBCs) Pedagogy

The major disadvantage of lecturing is often a waste of time. Students store the information in their short term memory and forget it all when the exam is over (Bjørke, 2014). According to Miller, lecture accounts for just about 5% of the average student retention rates (Miller, 2008). Learners who work on problem-solving with peers apply higher level thinking skills rather than learners who merely passively listen to a lecture in-class (Bjørke, 2014).

Architecture is an apprenticeship-based career. Discussions on the balance between theory and practice in architectural education have been going on for centuries. Educators argue that architecture institutions should educate students how to analyze, design, think, and explore a variety of solutions not simply how to do something right instead of wrong (ArchitectureWiwik, 15 July 2013). A study conducted by Ashraf Salama (2010) found that the integration of interactive learning mechanisms into lecture courses, such as theory courses, in architecture helps students to be in control over their learning while activating their understanding of the knowledge delivered in the typical lecture format (Salama, 2010).

LBCs in an architectural program account for a considerable share of the entire program. An analytical study of the architectural program delivered in Architecture and Urban Planning Department, Faculty of Engineering, Port Said University were performed by the author. It was found that (LBCs) account for about (33.3 %) in both first and second years, and (25%) in both third and fourth years. (LBCs) account for about (30%) of the entire program. The subject areas covered by (LBCs) are; humanity sciences, theory and history, and technology and science (as lighting and acoustics, and building technology). The author recommends that these (LBCs) have to be flipped to achieve the expected learning outcomes that targeting team-working, self-directing, critical thinking, and creativity skills that qualified graduates to be lifelong learners. Grounded on the background of PBL indicated in this paper, figure (6) illustrates the (LBC) in a framework of PBL pedagogy. Reviewing the literature related to applying PBL in LBSc in architectural education will be conducted to better understand the effectiveness, execution, and mechanisms of PBL in such courses. It will be summarized in the next section.

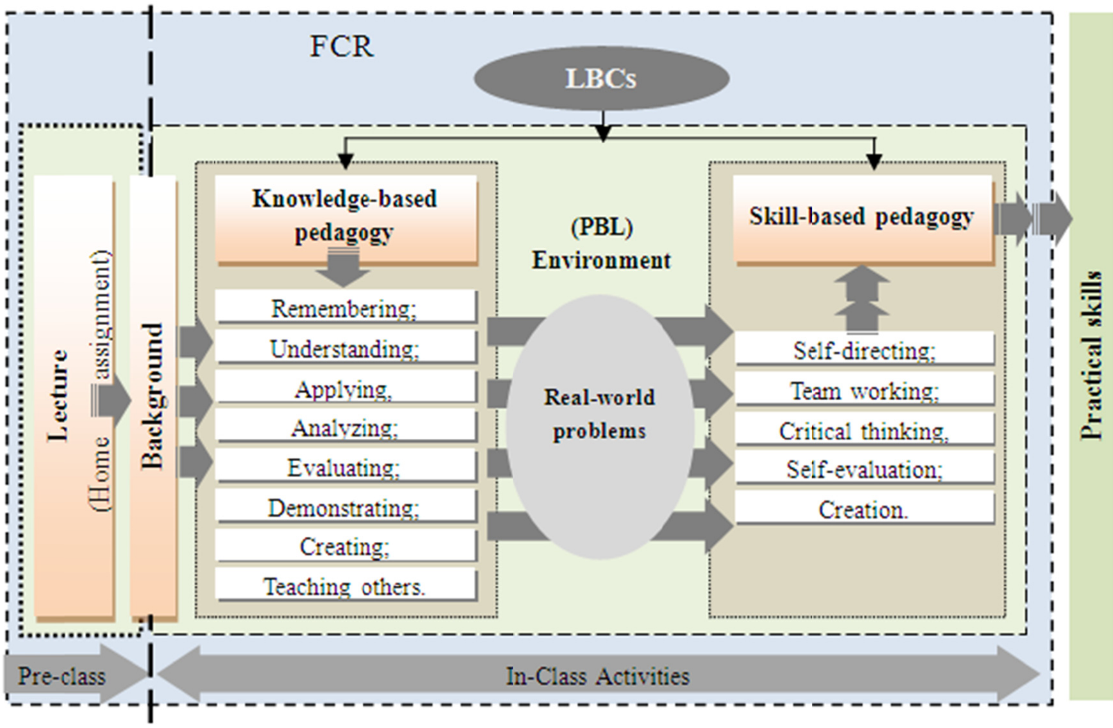

Figure 6. (LBC) in a framework of PBL pedagogy. Source: author after: (Bjørke, 2014; Galford, Hawkins, & Hertweck, 2015; Salama, 2005)

6. Literature Review of Flipping Architectural LBCs within a Framework of PBL

The literature on the effectiveness and execution of PBL environment in architectural education, particularly in LBCs, is inadequate although the concept of PBL was developed more than forty years ago. Via an online search, this paper compiled the available literature promulgated on that concern relevant to the paper's scope of; architectural education, FL, BPL, and LBCs. The experiences of two courses will be reviewed.

6.1 Sustainable Urban Development (SUD) Course

Steinemann examined a unique experience in his SUD course within a framework of PBL environment. In his experience, students determine a sustainability problem on their campus, and then develop a sustainability project to tackle that problem. Steinemann developed a course syllabus includes the objectives of the course, a sufficient background about the pedagogy used (PBL), and the two major expected products (the "project" and the "lessons learned"). He identified the cognitive levels during the PBL in the form of discussion, and written-reports. He designed a Report Format with specific topics related to the project-related problems and another Report Format regarding the lessons learned. Within the syllabus, the main project's topics are included. Another significant part of the PBL applied in that course is the student evaluation system. Steinemann stated that the evaluation system is important as it provides the instructor with a feedback, assesses student progress,

and enables him to adjust the course. It involves regularly questions posed by the instructor, weekly students′ self-evaluation, weekly open group discussions recorded by the instructor, and the two final reports on the lessons learned and the project. Throughout his experience, he reported students' appreciation about working on real-world projects and the experience of having the ownership of the project.

According to Steinemann experience, the PBL method provides students with skills for acquiring, analyzing, and applying knowledge. In addition, they simulate their professional practice and gain how to deal with stakeholders and interdisciplinary problems. They acquire professional communication skills through face-to-face experience. Applying PBL in teaching his course linked community with education through students′ projects.

The challenges he faced are represented in; 1) the balancing between giving the students the complete responsibility to solve the problems and the required feedback and guidance from the instructor to drive the path of the course in the right way, 2) the time of the semester is sometimes not enough for the implementation of students' projects. However, students' project reports with analysis and recommendations may use later by decision makers to implement deferred projects, 3) students' losing interest and discourage due to seeing few results with much effort and great time. Steinemann found that feeling success and encourage comes from discussing their project benefits, cost savings, and feasibility through the involvement with stakeholders and, 4) teaching a PBL course takes more time and effort than a LBC in terms of preparation, management, and assessment. That is in addition to the further effort needed from the instructor to work with the faculty administrators to obtain their support (Steinemann, 2003).

6.2 Acoustics and Lighting Courses

An experience of Worcester Polytechnic Institute (WPI) has integrated the three pedagogies of project-based learning, computer-based learning, and lecture-based learning in teaching the two courses of Acoustics, and Lighting. Students were assigned to solve real-life problems of real-world buildings within their surroundings.

In the WPI experience of delivering the Acoustics course, the first five weeks of the semester were devoted to a concentrated lecturing of the basic principles in tandem with assessment studies, while the last two weeks were dedicated for the project-based and computer-based methods. The students' evaluation system represents in submitting two reports of the course-related topics and a final report about the visual simulation and the retrofitting of real campus classrooms under different situations. They investigated and analyzed the current status using CATT then re-designed the spaces according to the results. Another crucial assignment is a poster presentation of the final project presented to the department community. It enables students to demonstrate their projects and compare and assess each other.

In their experience of delivering the Lighting course, two weeks were devoted to lecturing of the basic principles. Students' evaluation system is relied on three assignments. The first was to solve real-world problems and the two seconds were to analyze, measure, simulate, and make solution scenarios of a real-world museum in order to propose the optimum design in terms of lighting needs and energy saving. They investigated and analyzed the current status using DIALux. Similarly to the acoustics course, students presented a poster presentation demonstrating their projects on the faculty staff and the public. In a fostering initiative, the museum director shared students' posters on the museum website (Berardi, 2013).

Berdari (2013) reported a development of the design done by the students in both real cases of acoustics and lighting environment in terms of long-term sustainability. Such synthetics enable students to develop their professional attitude as it developed their critical evaluation, personal thoughts, and creativity and enabled developing the student's awareness of the relationship between physical principals and people perception. The progress of students' performance in this experience highlights the role of real-world problems in attracting students' attention to real buildings and making the sense of its related environmental and energetic problems.

7. A practical Guide to Apply FL Model on Lighting and Acoustics Course

Grounded on the previous literature, in the PBL environment there are two main points, the devising of the problems related to the course's topics, and the students' evaluation system. The design of the problems from the core of the course's topics is considered critical with respect to the course's outcomes. Problems should be included in the course syllabus. It can be scheduled on the table of contents over the lecture topics to cover the different modules. Designing the problems should be done by the course's instructor. Problems should be linked to the application on real-buildings. Turning the students' projects for implementation with the involvement of the institution's stakeholders and the department's community are from the heart of the PBL process. It simulates the students' professional practice and links education with the community. The creation of a simulated practical environment for the student during his formal study in architectural higher education is very crucial to prepare

students for professional practice.

With regard to the students' evaluation system, regularly and weekly assessment is needed in order to; enable the instructor to have the sufficient feedback to adjust his delivered lectures and ensure that the path of the PBL process in its right way. In tandem with final reports and a final project, students have the access to assess themselves and each others that consequently develops their critical evaluation and personal thoughts.

For a course in the nature of lighting and acoustics, computer-based learning methods along with field visits are essential to raise awareness of real-world buildings and the related sustainability issues. The next section will introduce the author's proposal of Lighting and Acoustics course based on PBL pedagogy.

Before starting a PBL class and to increase the learning outcomes and students' motivation, it is very important to prepare students to cope with, and adapt to the new pedagogical model. This comes with starting the course with a comprehensive tutorial session which defines the PBL environment (Smith, 2005).

Lighting and Acoustics course, according to the architecture department at the faculty of engineering at Port Said University, is a LBC delivered to second-year undergraduate students 3 hours/week. The nature of the course based on solving simple exercises of its related topics on virtual spaces. The lecture time is divided between lecturing and application time. Lecture time, often isn't enough for the application. Students complete their assignments at home in a form of worksheets.

The author suggests delivering the recorded lectures online via a Facebook group to the students weekly. Lectures can be delivered even in the form of PowerPoint or PDF formats. The author's proposal of classroom activities, considers solving real-world problems and evaluating scenarios. The cognitive levels that have been considered during the design process of the problems are; demonstration; discussion; practice-doing; and teach others. The expected skills in that experience are; team-working; self-directed nature; critical thinking; and creation. Table 2 shows the pre-class assignment (home lectures) and the corresponding PBL problems (in-class activities) distributed over the 14 weeks of the semester as a proposal for applying the integrated PBL FL model on lighting and acoustics course.

As the PBL and Project-Based Learning are often associated (Raine & Symons, 2005), the 15th week is devoted for project-based learning.

Table 2. The proposal of PBL related problems of lighting and acoustics course

Week	Pre-class assignment (Home lectures)	In-class activities PBL problem (Performed within groups according to PBL mechanism.)
1	1. Introduction: 1.1. Definition of the light. 1.2. Benefits of using daylight in illuminating buildings.	1. Students have to experience multi spaces with various lighting environments in their building and prepare a report about their subjective measurements. 2. Students could figure the expected energy and cost saving by the potential of replacing lamps with windows. [Answers could be presented on boards or digitally with display screens such as Mediascape. Conducting general discussion related to the pre-class assignment (lecture video)].
2	1.3. Eye and Sight (Visual Perception), Eye adaptation and accommodation, and visual comfort.	1. How to enhance occupants' visual comfort in your classroom environment? [Students have to suggest multiple solutions based on lecture and Internet search]. [Answers could be presented on boards or digitally with Mediascape].
3	1.4. Designing with Daylight.	1. How to modify your faculty building with various daylight strategies? Students can conduct a research and prepare a presentation of such strategies. [Answers could be presented on boards or digitally with Mediascape].
4	2. Daylight Factor 2.1. Measurement of Sky Component for windows. 2.2. Measurement of Externally Reflected	1- Applying physical measurements of SC and ERC for the classroom environment. 2- Applying the same problem with various windows dimensions and location for a specific space amongst groups and comparing the results.

	Component for window.	
5	2.3. Measurement of Internally Reflected Component for wall Windows. 2.4. Measurement of Daylight Factor.	1- Applying both manual and metric physical measurements of DF for the classroom environment. 2-Applying the same problem with various windows dimensions and location for a specific space amongst groups and comparing the results.
6	3. The Glare 3.1. Levels of Glare 3.2. Calculation of the Glare Index.	1- Applying hand-held physical measurements of the glare index for various points in the classroom environment. 2- Applying hand-held physical measurements of the glare index for various windows cases in various spaces in the faculty.
7	Mid Term Exam	
8	4. Designing with Lamps: 4.1. Types of Lamps. 4.2. Measurements of the required numbers of lamps for a space.	1- Applying both manual and metric measurements of required number of lamps to illuminate real-world spaces (classroom, library, etc.). 2- Check whether ceiling light fixtures will be adequate to illuminate your desk. Is this an appropriate value? [Every group has to survey factors they need to perform analysis] 3- Comparing daylighting measurements and electric lighting and giving notes.
9	5. Introduction of Acoustics: 5.1. Behavioral characteristics of sound. 5.2. Wavelength, frequency & intensity. 5.3. Distribution of sound; transmission, reflection and absorption. 5.4. The Ear and Perception of Sound.	1- Select a large space inside your building and observe and evaluate the acoustics in this space when it is empty and full of people. Discuss the acoustics with the building's users to know more about their impression. [Groups prepare a report to address their opinions about the architectural design of the space from the acoustics point of view]. [This survey represents an introduction and brainstorming for Design of Auditorium Halls]. 2- Perform metric measurements of the sound pressure level of different spaces in your building, and give notes.
10	6. Design of Auditoriums: 6.1. Open-air cinema design: Factors affect open air cinema design: site; wind; temperature; and humidity.	1- Identify noise sources on your campus and suggest measurements to avoid noise. 2- How the wind alters sound propagation? Support your answer with examples. 2- How temperature can impact sound propagation? Support your answer with examples. 3- How humidity alters sound propagation? Support your answer with examples. [Every group can tackle one problem, and then the entire class shares their results].
11	6.2. Techniques of closed auditoriums design (speech halls; cinema and music halls; opera and theatres) :(Ceiling – Plan Shape – Side Walls – Rare Wall – Balcony Window).	1- Analyze a large hall in your faculty with respect to Ceiling; Plan Shape; Side Walls; Rare Wall; and Balcony Window if presented. Discuss the acoustics with the building's users to know more about their impression. 2- A field trip to a large auditorium is required (for an instant: the Egyptian Opera House), students have to perform subjective measurements paired with concurrent physical sound measurements (dB, taken with handheld devices).
12	7. The Sound Absorption Materials 7.1. Conditions of choosing the absorption materials. 7.2. Types of absorption materials. 7.3. Absorption coefficient.	1- Conduct a research on types of absorption materials and criteria of preference. 2- Deduce factors influencing the acoustic performance of sound absorptive materials.
13	7.4. Measurements of R_{t60} (Reverberation Time).	1- Perform physical sound measurements for R_{t60} in a series of spaces on campus.
14	8. Noise Control And Sound Insulation 8.1. Kinds of Noise. 8.2. Air-borne noise.	1-Develop acoustical performance criteria based on the evaluation/analysis of a space in your building. 2-Refine the design of the space to ensure the successful application of the design

	8.3. Structure borne noise.	criteria.
15	Project-based learning	Students will be expected to prepare a written design analysis of a specific visual and acoustical environment within the campus. Performance specifications for the space will be established, and each student will be required to design, and/or refine an existing design of the selected space.

8. Conclusion

This paper discloses an approach to transform the present higher educational pedagogical methods within a framework of FL. The FCR model is structured on the three related and correlated pillars; pedagogy, technology, and space. Pedagogy is promoted by technology and enabled and motivated by space. Technology is established by space and space is extended by technology. Figure 7 summarizes the staple principles of the FCR.

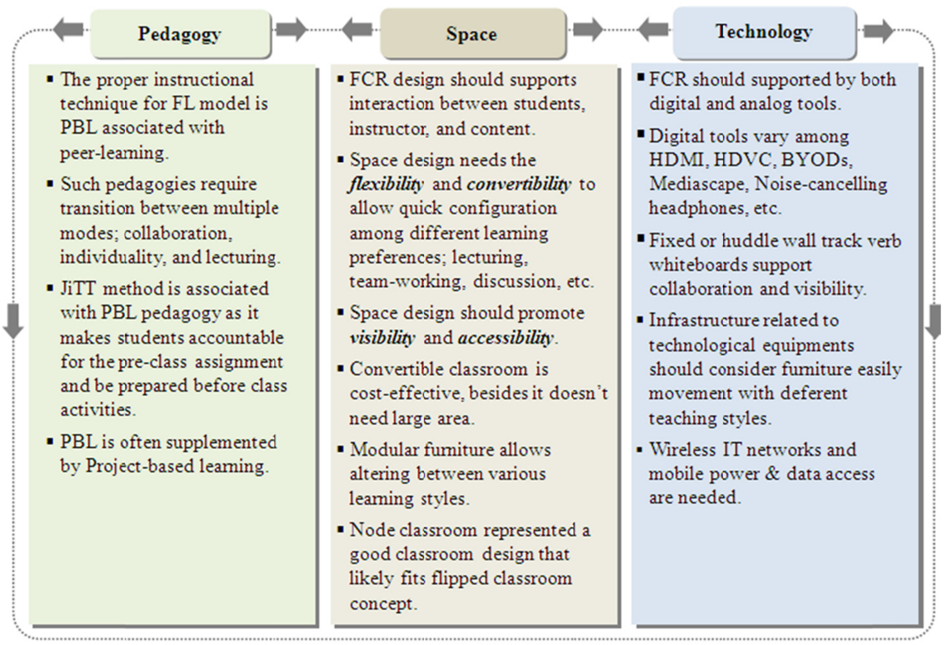

Figure 7. The theoretical framework of FCR environment

There are pronounced prospects of FL concept that can't be dismissed. The concept of FL ensures students' engagement and collaboration. It expands the time devoted to activities and application. Establishing the FCR requires a complementary infrastructure, both physical and human infrastructure. The instructor alone can't flip his/her classroom without the aid and support from the institution's stakeholders. Physical infrastructure, as being indicated before, requires specific wiring regarding to the technology. That includes the Internet, the technological equipment, and furnishing. Human infrastructure includes establishing the concept of FL among faculty members and providing them with the adequate background of its related pedagogies. Applying such pedagogies implies the conscious design of the related real-world problems and the proper student assessment methods.

TCR can be easily turned to FCR taking into account the infrastructure supplies. As being mentioned previously that the cost of FCR is higher than TCR with regard to the technological demands and space furnishing, nevertheless, there are minimal respects in which we can switch TCR to FCR. The conventional computer laboratory can act as FCR as it has the minimal requirements of the needed infrastructure, giving consideration to the elements that have already mentioned in the technology portion such as internet access and BYODs.

9. Recommendations and Further work

The creation of PBL pedagogy in an integrated FL environment in delivering Lighting and Acoustics course establishes the students' ability to work within an overall creative architectural design environment. Through the

experience of lighting and acoustics course that addressed in this paper, computer-based technology should be included. 3D modeling and simulation software are essential in such building physics-based courses. The theoretical PBL base that founded by this study has to be executed on the ground. The next research step is to check the experience and perform subjective measurements by a questionnaire, and measure the academic achievement. That is due to stand on the applicability of this model and the extent of how to take advantage of such application.

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